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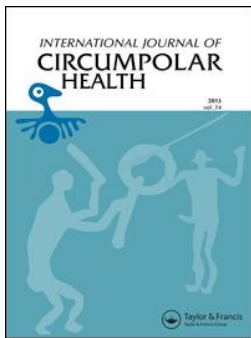
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## Association between dog ownership and type 2 diabetes in later life: the Helsinki birth cohort study

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### ABSTRACT

Dog ownership has been reported to have beneficial effects on physical activity and emotional well-being, both known to reduce the risk for type 2 diabetes (T2D). The aim of this study was to evaluate the association between dog ownership during the whole life course and having T2D in later life. The study subjects consisted of 731 people (307 men and 424 women) from the Helsinki Birth Cohort Study. We assessed dog ownership with questionnaires, for every decade of life as well as current dog ownership. We investigated the associations between dog ownership and T2D with generalised estimating equation models and with generalised linear models. At a mean age of 71.0 (standard deviation [SD] 2.6) years, 13% of the participants had T2D. Dog ownership prior to the clinical examination was not associated with T2D ( $p \geq 0.51$ ). In men, but not in women, current dog owners had greater odds of having T2D compared with the non-owners when adjusted for age when clinically examined, socio-economic status, smoking, leisure-time physical activity, chronic diseases (OR = 3.32, 95% confidence interval 1.25–8.79,  $p = 0.016$ ). In the age group of people around 70 years, dog ownership is not associated with reduced odds for developing T2D.

**Abbreviations:** BMI: body mass index; CI: confidence interval; GEE: generalised estimating equation; HBCS: Helsinki Birth Cohort Study; KIHD: Kuopio Ischemic Heart Disease; LTPA: leisure-time physical activity; MET: metabolic equivalent of task; OGTT: oral glucose tolerance test; OR: Odds ratio; SD: standard deviation; SES: socio-economic status; T2D: type 2 diabetes

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### KEYWORDS

Aged; Finland; diabetes mellitus; leisure activities; public health practice; sedentary lifestyle

## Background

The number of people with type 2 diabetes (T2D) is increasing globally [1]. Well-known risk factors for T2D include physical inactivity, obesity, unhealthy diet and genetic predisposition [2]. Worldwide, 1 in 11 adults has T2D and 1 in 4 adults is not physically active enough [1,3].

In several developed countries, the rates of dog owners are high; in the United States and in Australia approximately 40% of households have at least 1 dog [4,5]. Dog ownership or walking a dog seems to associate with additional physical activity or higher levels of physical activity in children as well as in adults [6–9]. Further, pet ownership may have a beneficial influence on psychological stress and symptoms of depression [10–12]. Both a physically active lifestyle and emotional well-being are known to associate with a reduced risk

for T2D [13,14]. Thus, it could be expected that dog owners have a low risk to develop T2D. However, only a few studies have focus upon the association between dog ownership and diabetes; the dog owners seem to have lower risk for self-reported diabetes than the non-dog owners [15]. The possible effect of dog ownership during the whole life course on the probability of T2D is unknown.

The aim of this study was to evaluate the association between dog ownership during the whole life course and having T2D in later life.

## Methods

### Study design and participants

This study is an observational cohort study. The subjects of this study belong to Helsinki Birth Cohort Study

(HBCS) including 8760 men and woman born in Helsinki University Central Hospital, Finland, between the years 1934 and 1944 and who were alive in 1971 [16]. We used random-number tables to select a subset of people who attended a clinical examination between 2001 and 2004. Of the 2902 invited, 2003 men and women participated in the examination. A follow-up was conducted about 10 years later. A total of 1404 people were still traceable and invited to re-examination. A total of 1082 men and women attended the clinical examination between 2011 and 2013. Of them, 731 (307 men and 424 women) with adequate information on dog ownership and on diabetes were included in this study.

### **Dog ownership**

We obtained information on current as well as dog ownership during their lifespan (0–10 years, 11–20 years, 21–30 years, 31–40 years, 41–50 years, 51–60 years, over 60 years) from a questionnaire sent between December 2013 and January 2014 to those who participated in the clinical examination.

### **Type 2 diabetes**

The study subjects were determined to have T2D if they have reimbursement for diabetes medication or if they have diagnostic values for T2D in a standard 2-h 75 g oral glucose tolerance test (OGTT) according to the WHO 1999 guidelines, or if their haemoglobin A1c value was  $\geq 48$  mmol/mol (6.5%). We obtained data on reimbursable diabetes medication from the register of the National Finnish Social Insurance Institution [17]. In order to receive reimbursable medication for diabetes in Finland, the treating physician composes a medical certificate including the history of diabetes. Expert physicians at the National Finnish Social Insurance Institution review this medical certificate. When fulfilling the criteria for diabetes, the subject is entitled to reimbursable medication for diabetes and the information will be entered into a nationwide register [17]. All study subjects without diabetes diagnosis underwent a standard 2-h 75 g OGTT after overnight fasting according to the WHO 1999 guidelines [18]. First, the fasting plasma glucose was measured and then the study participants ingested the 300 ml solution containing 75 g anhydrous glucose and 1.6 g citric acid. After 2 h, a blood sample was drawn. The criteria for T2D were fulfilled when the fasting glucose value  $\geq 7.0$  mmol/L and/or the 2-h value  $> 11.0$  mmol/L [18].

### **Body mass index and leisure-time physical activity**

We calculated body mass index (BMI) as measured weight (kg) in light indoor clothing divided by height squared ( $\text{m}^2$ ). We determined leisure-time physical activity (LTPA) by a validated Kuopio Ischemic Heart Disease (KIHD) 12-month history questionnaire asking the average duration, frequency and intensity of LTPA [19,20]. Based on this data, we assessed a metabolic equivalent of task (MET) value for each activity according to the database of MET-values [21].

### **Chronic diseases, smoking, alcohol consumption and educational attainment**

We obtained information on chronic diseases such as diabetes, hypertension, heart failure, coronary heart disease, claudication, stroke, cancer, osteoporosis, depression, asthma, or pulmonary emphysema as well as smoking habits, alcohol consumption and educational attainment from questionnaires. We used educational attainment to describe socio-economic status (SES).

### **Statistical analysis**

Data are shown as means (standard deviation, [SD]; 95% confidence intervals, [95% CI]). The differences in participants' characteristics between T2D vs. non-T2D were compared with t-test for continuous variables and with a chi-square test for categorical variables. The association between dog ownership during each decade of life and T2D was investigated with generalised estimating equation (GEE) – models. The association between current dog ownerships and T2D was analysed with logistic regression. Results are reported as odds ratios (OR). All analyses were adjusted for age when clinically examined, sex, SES, LTPA, smoking, and chronic diseases. p-Values  $< 0.05$  were used as a threshold for statistical significance. Analyses were performed with Stata/SE 13.1 and 14.1 and Stata/MP 15.1 (StataCorp, 4905 Lakeway Dr, College Station, TX 77,845).

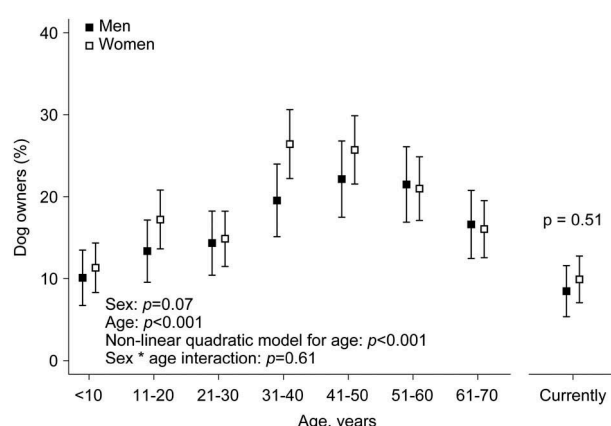
### **Results**

Baseline characteristics of the study subjects are shown in Table 1. Of the study subjects, 13% had T2D and 53% had a history of dog ownership during their lifetime. No significant differences between men and women were observed in relation to dog ownership (Figure 1). The current dog owners had 14.7 MET-h/week (95% CI 11.9–17.5,  $p < 0.001$ ) higher volume of LTPA than the non-dog owners. Subjects with T2D had 7.5 MET-h/week (95%

**Table 1.** Baseline characteristics of the study subjects (N=731).

Characteristic		
Males, n (%)	307	(42)
Age when clinically examined, years, mean (SD)	71	(2.7)
Body mass index, kg/m <sup>2</sup> , mean (SD)	27.0	(4.7)
Type 2 diabetes, n (%)	94	(13)
Lifetime history of smoking, n (%)	371	(52)
Alcohol consumption, n (%)		
Weekly	369	(52)
1–2 Times per month	275	(39)
Never or quit drinking	62	(9)
Educational attainment (years), mean (SD)	12.6	(3.6)
Total LTPA, MET-hours/week, median (IQR)	24.6	(33.9)
Chronic diseases, n (%)		
0 Disease	234	(32)
1 Disease	301	(41)
≥ 2 Diseases	196	(27)

T2D, type 2 diabetes; SD, standard deviation; LTPA, leisure-time physical activity; MET, metabolic equivalents of task; IQR, interquartile range.



**Figure 1.** The generalised estimating equation model for percentage of dog owners at different age groups (n = 731). Current dog ownership is analysed separately with logistic regression.

CI 5.0–10.0,  $p = 0.001$ ) lower volume of LTPA than the subjects without T2D. In Table 2, a multivariable-adjusted model for T2D by age group and dog ownership is shown.

### Association between dog ownership and type 2 diabetes

No significant age by dog ownership interaction effects was found in all subjects (Figure 2(a)), men (Figure 2(b)) or women (Figure 2(c)) when adjusted for age when clinically examined, sex, SES, LTPA, chronic diseases, and smoking ( $p$  for interaction  $\geq 0.21$ ). Furthermore, no significant main effect for age or dog ownership was detected in an adjusted model (Figure 2(a–c)).

In all subjects, the current dog owners had greater odds of having T2D (OR = 2.23, 95%CI 1.12–4.44,  $p = 0.023$ ) compared with the non-owners when adjusted for age when clinically examined, sex, and SES, LTPA, chronic diseases, and smoking (Figure 2(a)). We found no significant

**Table 2.** The generalised estimating equation model for type 2 diabetes by dog ownership and age group (n=682).

Independent variables	OR (95% CI)	p-Value
Dog owners		
No	1 (Ref)	
Yes	1.03 (0.74–1.43)	0.871
Sex		
Male	1 (Ref)	
Female	0.57 (0.46–0.7)	< 0.001
Dog owners by sex interaction	1.25 (0.8–1.95)	0.319
Age (years)		
≤ 10	1 (Ref)	
11–20	0.99 (0.72–1.37)	0.966
21–30	0.99 (0.72–1.38)	0.975
31–40	0.98 (0.7–1.35)	0.888
41–50	0.98 (0.71–1.36)	0.899
50–60	0.99 (0.71–1.36)	0.93
≥ 60	0.99 (0.72–1.37)	0.964
Age of clinical assessment	1.04 (1.01–1.07)	0.023
Educational attainment, years	0.97 (0.95–1)	0.021
Lifetime history of smoking		
No	1 (Ref)	
Yes	1.32 (1.08–1.6)	0.006
LTPA, MET-hours/week	0.86 (0.83–0.89)	< 0.001
Chronic diseases		
0 Disease	1 (Ref)	
1 Disease	1.5 (1.19–1.88)	0.001
≥ 2 Diseases	2.04 (1.61–2.59)	< 0.001

OR, odds ratio; CI, confidence interval; LTPA, leisure-time physical activity; MET, metabolic equivalent of task.

sex by dog interaction ( $p = 0.27$ ) effect on T2D in a fully adjusted model.

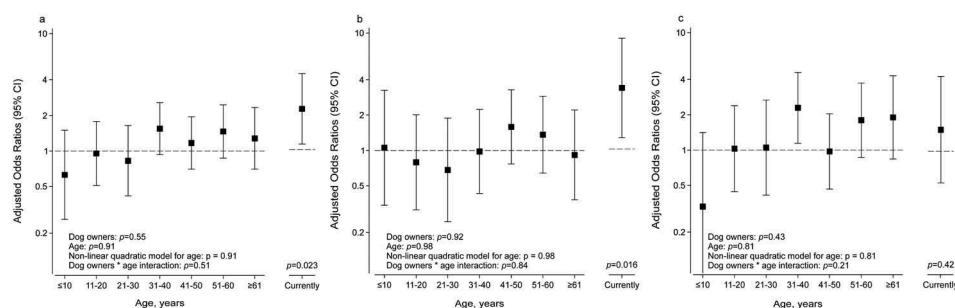
In men, the current dog owners had significantly greater odds of having T2D (OR = 3.32, 95% CI 1.25–8.79,  $p = 0.016$ ) compared with non-owners in a fully adjusted model (Figure 2(b)).

In women, no significant association was found between current dog owners and the non-owners for the odds of having T2D (OR = 1.53, 95%CI 0.54–4.34,  $p = 0.42$ ) when adjusted for age when clinically examined, SES, LTPA, chronic diseases, and smoking (Figure 2(c)).

## Discussion

According to our study findings, at the mean age of 71 years, 13% of the study participants had T2D. Having a history of being a dog owner in childhood, in adolescence or in adulthood did not influence the association of having T2D in later life. Men who were current dog owners seemed to have greater odds to have T2D than the non-owners; in women, such an association was not observed. To the best of our knowledge, this is the first study to evaluate the association between dog ownership during the whole life course and having T2D in later life.

In our study cohort, the prevalence of T2D was high. This observation is in line with previous Finnish study findings in the same age groups [22,23]. Ageing is a well-established risk factor for T2D [24]. Ageing is associated



**Figure 2.** Generalised estimating equation model for type 2 diabetes by dog ownership and age group (a) in all ( $n = 682$ ), (b) in men ( $n = 291$ ), and (c) in women ( $n = 391$ ). Current dog ownership is analysed separately with logistic regression. All analyses are adjusted for age when clinically examined, socio-economic status, leisure-time physical activity, smoking, chronic diseases, and (a) also for sex.

with a loss of muscle mass and increased muscle weakness, which in turn increases insulin resistance and the risk for T2D [25].

Dog ownership as a child, as an adolescent or as an adult was not associated with having T2D in later life. The study subjects were born in the 1930s and 1940s. At the time in Finland at and a few decades later, dogs were mostly kept as working dogs such as watchdogs or hound dogs. From the 1970s onwards, the dogs became more common as pets, and at the same time dog walking became more common [26]. The change in the reason for dog owning over time might explain why dog ownership as a child, as an adolescent or as an early or middle adulthood does not influence the risk to develop T2D in later life.

According to our study findings, in men, current dog ownership increased odds for T2D but not in women. Our study observations differ from U.S. cross-sectional study findings reporting that current dog owners have a lower risk for self-reported diabetes than non-dog owners [15]. However, generally, it is known that self-reported rates of diabetes are lower than rates based on comprehensive glucose measurements.

The study observation that current dog owners seem to have increased odds for T2D was surprising. There are some explanations for this observation. Guidelines for treating T2D emphasise the role of regular physical activity [27]. Dog walking has been found to be an easily accessible, regular, and sustainable form of physical activity for the people with T2D [28]. Thus, possibly, some patients with T2D are recommended to acquire a dog for regular exercise. Our study observations support this explanation: people with T2D move less than people without T2D and current dog owners move more than non-dog owners. In the present study, we do not have information on when the dog was acquired in relation to diagnose of T2D and what were the reasons behind the

dog acquiring. Secondly, it has been shown that around half of the dog owners walk with their dog [29]. In the present study, we were unable to assess whether the dog owners walked with their dog or not. Thirdly, some people may have forceful reward behaviour [30]. In practice, this means that some people reward themselves for physical activity, e.g. dog walking, with increased food or snack intake and sedentary lifestyle of the rest of the day [30]. Unhealthy diet and sedentary lifestyle are among the well-known risk factors for T2D [24]. The reason, why current men dog owners seem to have increased odds for T2D but not in women remains to be determined.

### The strengths of the study

Our study cohort is globally unique, large and well documented with the data on dog ownership during the whole life course. Data on T2D among the study subjects are comprehensive; all study subjects without a history of diabetes had a 75 g standard 2-h OGTT and haemoglobin A1c measured detecting undiagnosed T2D. In addition, we have register data of reimbursements for diabetes medication.

### Study limitations

We assessed dog ownership by retrospective self-reporting, which includes some recall bias. However, we assumed that owning a dog is something that people recall correctly. Also, the recall bias is possible in relation to the age of dog ownership. Further, being a dog owner does not mean the same as being a dog walker; we were not able to separate dog ownership and dog walking from each other. We are also missing the information about the reasons for a dog acquiring and what type of dog was acquired. Moreover, information on dog owning



and diabetes was limited to 68% of the study participants in the clinical examination in 2011–2013. The study participants (N = 731) in the years 2011 to 2013 represent 36% of the years 2001 to 2004 study cohort (N = 2902). These factors may have influenced our results.

## Conclusions

As expected the prevalence of T2D was high in the age group of people around 70 years. In people born in the 1930s and 1940s, dog ownership was not associated with reduced odds for T2D in later life. Health-care professionals should motivate everyone, including dog owners, to follow a healthy lifestyle. Further studies covering the whole life course are needed to investigate whether the situation is different in the 21st century.

## Ethical approval

The studies were conducted according to the guidelines laid down in the Declaration of Helsinki, and clinical procedures involving human subjects were approved by the Coordinating Ethics Committee of the Hospital District of Helsinki and Uusimaa. All study participants provided written informed consent.

## Availability of data and materials

The data used and analysed in this study are included within the article.

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## Disclosure statement

No potential conflict of interest was reported by the authors.

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